# Space Weather Technical Forecast

Issued on Tuesday, 04 April 2023 at 01:30 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: Chance of Minor Geomagnetic Storms Days 1-2. Periods of Active electron fluence expected Day 1-2. Slight chance of M-class flares (R1-R2; Minor-Moderate radio blackouts) throughout.**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity has been Low over the past 24 hours, with a few small C-class flares observed. The largest being a C2.8 flare at 03/2353 UTC from AR3270. There are currently four sunspot regions on the disc. Most are small and simple with little magnetic complexity. The most notable sunspot group remains AR3270 in the southern hemisphere, west of the Earth-Sun meridian. The overall size and longitudinal extent of the region has gradually increased and there is greater magnetic looping evident in coronagraph imagery. The region also contains a small, magnetic delta structure. The analysis and modelling of Coronal Mass Ejections (CMEs) detected in available imagery over the past 24 hours suggest no significant Earth-directed component.

**Solar Wind / Geomagnetic Activity:** The solar wind, as measured at L1 by ACE and DSCOVR, varied between Elevated and Slightly Elevated levels (~480-540km/s) due to the ongoing enhancement from CH88/-. Density was generally Average but increased to slightly Above Average from around 03/1300 UTC. The phi angle was predominantly negative (towards the Sun). The IMF was weak (below 8nT), and the north-south component was also weak with fluctuations between +5/-5nT. Geomagnetic activity was mainly at Quiet to Unsettled (Kp1-3) levels, but with an Active (Kp4) interval 03/1800-2100 UTC.

**Energetic Particles / Solar Radiation:** High energy proton enhancement (greater than 10MeV) has been at background levels. The high energy electron flux (greater than 2MeV), as measured at GOES16 increased from Moderate to High levels early on in the UTC day on 03 Apr. High levels were sustained until 03/1950 UTC when electron flux dropped back to Moderate levels again. A peak flux of 4290pfu was observed at 03/1455 UTC. The associated 24-hour fluence increased above the Active (1e8 integrated pfu) threshold from 03/1500 UTC and remained above at the end of the UTC day on the 03 Apr. At 04/0001 UTC the observed fluence was 1.31e8 integrated pfu.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Solar activity is likely to continue at Low levels, with a Slight Chance of becoming Moderate.

**Solar Wind / Geomagnetic Activity:** Although no Earth-directed CMEs are expected, there is a slight chance of a glancing impact from a CME at Earth later on Day 1 (04 Apr).

Solar winds are likely to remain at predominantly Slightly Elevated to Elevated levels on Day 1, owing to the influence of a coronal hole HSS. On Day 1 or Day 2 (05 Apr) Earth is expected to connect to the HSS from one or more small coronal holes. Solar winds are forecast to return to generally Elevated levels and this will probably continue into Day 3 (06 Apr) before easing on Day 4 (07 Apr)

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back to Elevated or Slightly Elevated levels.

Generally Quiet to Unsettled geomagnetic activity is expected at first on Day 1, with a chance of Active intervals or perhaps isolated G1/Minor Storm conditions, particularly should any CME effects occur. There is an increasing probability of Active or G1/Minor Storm intervals later in the day, or on Day 2. Activity should generally become Quiet to Unsettled again on Days 3 and 4 with a reducing risk of Active or G1/Minor Storm conditions in the absence of any further CMEs.

**Energetic Particles / Solar Radiation:** High energy proton flux (greater than 10MeV), as observed by GOES-16 is at background levels and is expected to remain so pending any significant sunspot development.

The high energy electron flux at GOES16 is at Moderate to High levels to start the period. There is a slight chance that weak CME influences later on Day 1 (04 Apr) could suppress observed flux values temporarily back towards Normal Background, adding slight uncertainty into the forecast. As the HSS from one or more coronal holes affects Earth from Day 1 (04 Apr) or Day 2 (05 Apr), it is likely that flux values will subside for a period. Electron counts would be expected to rise again later on Day 3 (06 Apr) into Day 4 (07 Apr) as geomagnetic activity subsides, bringing an increased chance of High electron flux levels being reached again.

Fluence levels start the period just above the Active threshold. Activity may fall back below this threshold for a time on Day 1 but should generally remain above this level. Following the expected increased geomagnetic activity associated with the onset of one or more coronal hole HSS on Day 1 and/or Day 2, fluence should more persistently drop below the Active threshold, but may reach Active levels once again on Day 4 as Geomagnetic activity subsides and electron counts rise.

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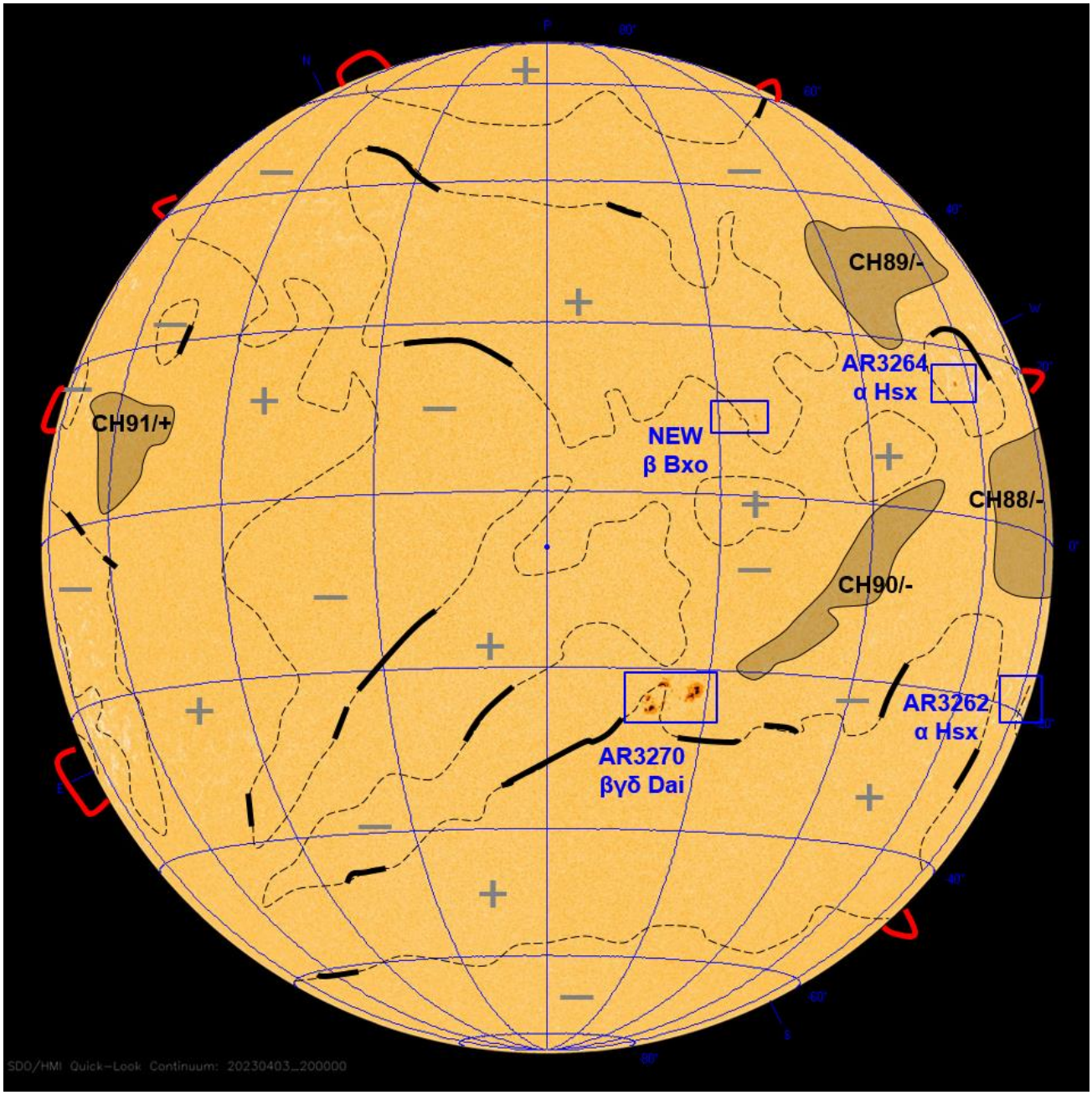
**Figure 1. Solar Analysis Valid 03/2000 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

There have been a number of generally small, but complex to analyse CMEs over the last few days. Although modelling would suggest that these are not Earth-directed, there remains a slight chance of a glancing impact at Earth on Day 1 (04 Apr). This is supported by a small number of MOSWOC ENLIL ensemble perturbations, however, any impacts will most likely be minor.

Solar winds are currently between Elevated and Slightly Elevated levels, a result of the ongoing influence of the HSS from CH88/-. A transition from this into a connection with the next HSS (CH89/- and/or CH90/-) is likely to take place between Days 1 and 2 (04 and 05 Apr), with CH90/- expected to be the dominant feature. Solar winds are forecast to return to generally Elevated levels and this will probably continue into Day 3 (06 Apr) before easing into Day 4 (07 Apr) back to Elevated or Slightly Elevated levels. Currently the Met Office Enlil model output appears to be signalling this forecast evolution well.

Generally Quiet to Unsettled geomagnetic activity is expected at first on Day 1, with a chance of Active intervals or perhaps isolated G1/Minor Storm conditions, particularly should any CME effects occur. There is an increasing probability of Active or G1/Minor Storm intervals later in the day, or on Day 2 due to the combined influence of coronal hole HSS and possible transitory CME effects. Activity should generally become Quiet to Unsettled again on Days 3 and 4 with a reducing risk of Active or G1/Minor Storm conditions in the absence of any further CMEs.

| Geo-Magnetic Storm<br>Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 30 | 30 | 10 | 5 |
| Strong | G3 | No | 5 | 5 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections – Nil expected

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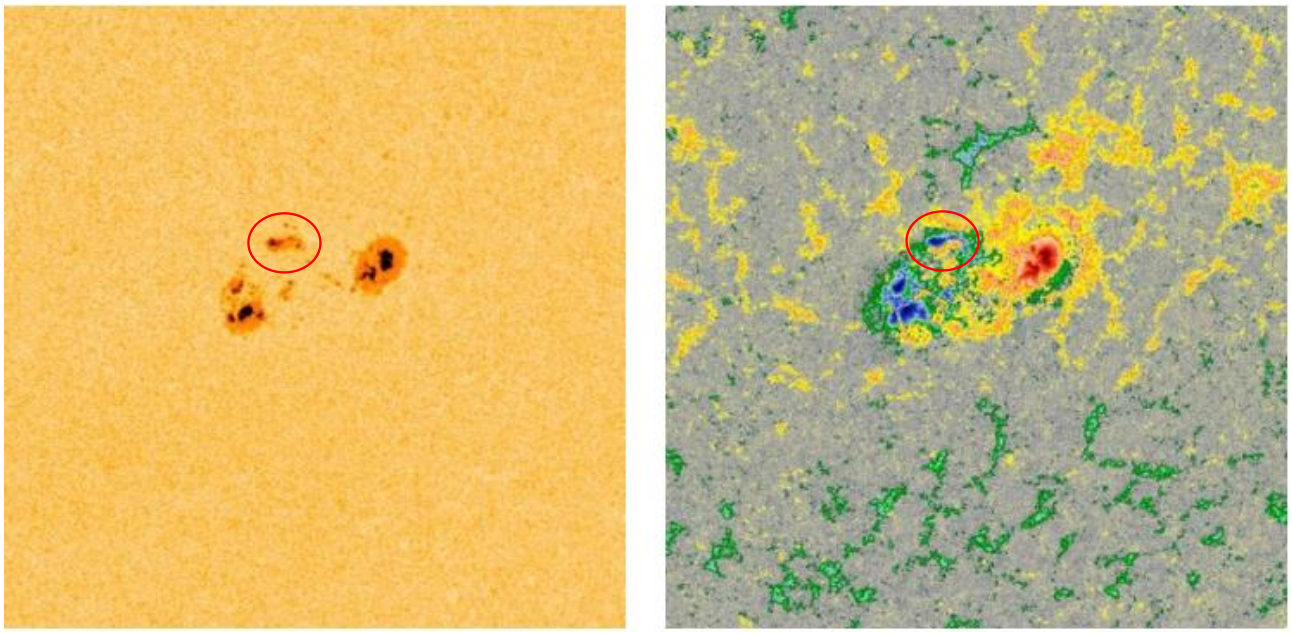
## Radio Blackouts - X-Ray Flares:

The four-day forecast period is currently expected to see a relatively muted flare risk, with a limited number of mainly small and simple regions on the visible disc. AR3270 will continue to be closely monitored and further development could see an increase in significant flare probabilities during the period. Two small, simple regions will rotate over the western limb in the next couple of days. However, there is an indication for returning or new regions to arrive across the eastern limb during the period. Soundings suggest the most active of these regions may emerge in the northern hemisphere on Day 1 or 2 (04 or 05 Apr) with a potential associated uptick in forecast flare risk. Solar activity is likely to continue at Low levels, with a Slight Chance of becoming Moderate.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | No | 15 | 15 | 15 | 15 |
| Very Active | R3 to R5 X Class | No | 1 | 1 | 1 | 1 |

**Figure 2: Latest HMI Intensitygram - Flattened and HMI Colorized Magnetogram for AR3270. Delta spot circled.**



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## Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES-16 is forecast to remain at background levels, pending any significant sunspot development. Any notable flare activity from AR3270 gives the greatest risk of levels reaching S1.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 5 | 5 | 5 | 5 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

## High Energy Electrons Event (≥ 2MeV):

The high energy electron flux at GOES16 is at Moderate to High levels to start the period. There is a slight chance that weak CME influences later on Day 1 (04 Apr) could suppress observed flux values temporarily back towards Normal Background, adding slight uncertainty into the forecast.

As the HSS from CH89/- and/or CH90/- affects Earth, either from later Day 1 (04 Apr) or on Day 2 (05 Apr), it is likely that some compression of the electron belts will take place and electron flux values return towards Normal Background levels for a period of time. Electron counts would be expected to rise again later on Day 3 (06 Apr) into Day 4 (07 Apr) as geomagnetic activity subsides, bringing an increased chance of High electron flux levels being reached again.

Fluence levels start the period just above the Active threshold. Activity may fall back below this threshold for a time on Day 1 but rise again in-line with the diurnal electron cycle. Following the expected increased geomagnetic activity associated with the onset of one or more coronal hole HSS on Day 1 and/or Day 2, fluence should more persistently drop below the Active threshold, but may reach Active levels once again on Day 4 as Geomagnetic activity subsides and electron counts rise.

MOSWOC REFM output is currently under-forecasting fluence levels, appearing to be lagged from the forecast values by around 24-hours. Applying an approximate 24-hour lagged trend to forecast data would seem to be a reasonable assumption for the current forecast. Recurrence has persistently over-forecast electron fluence in recent days and values are considered to high relative to expected values.

| GEO Electron Environment Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | Yes | 100 | 60 | 20 | 40 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

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**Figure 3: Latest GOES-16 Electron Flux and MOSWOC REFM output**

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